TM-1055
2280.000

Fermilab

AN IMPROVED DIGITAL MEASUREMENT AND COMPARISON MODULE

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1. Original Application:

The measurement of various parameters and comparing the readings against predetermined limits is an important function of any monitoring and control system. Magnet currents, cooling water temperatures, flammable gas concentration, and oxygen concentration in air, are a few of the applications where, because of life threatening conditions, or damage to expensive equipment, a reliable measurement and control device is necessary. It was for this reason that a digital comparator module was designed and first used to measure magnet current as part of a Radiation Safety System.

Soon after the first implementation, other applications were suggested such as, monitoring the voltage drop on the leads of a cryogenic magnet. The module worked very well in these other applications. Since the original design was for use in a transrex power supply, interface circuitry, un-necessary for other uses, was included on the same board with the measurement and comparison circuitry. After some practical experience was gained with the modules in service, several changes and improvements were suggested for the design of a new module that would be more flexible in applications other than in a power supply.

2. Original Attributes and Shortcomings:

The original digital current monitor module was perfectly matched to its application as a magnet current monitor. The module has two independent channels for protection from component failure and subsequent loss of protection. Each channel monitors the same input signal redundantly. Each channel has an input isolation amplifier for protection from common mode voltages up to 1000 volts. Following the isolation amplifier is a 4 1/2 digit analog to digital converter. The two most significant full digits from the multiplexed output are latched and compared against two settings. One setting is an upper limit, the other is a lower limit. All four full digits are displayed. The half digit and polarity information are not used in any way. If the displayed data goes over the preset upper limit, a relay is de-energized breaking a circuit to the external world. Likewise, if the displayed data goes under the lower limit a relay is de-energized.

In applications other than current monitoring, several shortcomings became apparent. The original module has a four digit display, but tests only the first two digits against a preset limit. The module is not sensitive to polarity, and uses the absolute value of the reading. Probably the most serious shortcoming is the lack of overflow protection. If an input signal overflows the dynamic range of the analog to digital converters, the display simply overflows through zero. This is not really a serious problem when measuring a 50 millivolt shunt. A transrex would have to go over 10,000 amps to overflow the module. For a 5000 amp supply this situation is not going to persist even if it does happen. When measuring other sources this could be a serious problem. The module has only one set of normally closed contacts per setting, which is inconvenient for many applications such as alarms which require power to be applied only in a trip condition.

With these attributes, and a broad range of new applications in mind, a new module was designed.

3. An Improved Version:

Like the original module, the new module has two independent measurement channels. Each channel has two independent level settings with four digit resolution on each. Each of the four level settings can be programmed to trip under any of the following conditions:

Reading greater than limit, either polarity
Reading greater than limit, positive polarity only
Reading greater than limit, negative polarity only
Reading less than limit, either polarity
Reading less than limit, positive polarity only
Reading less than limit, negative polarity only

A trip will also occur on the greater than limit settings when the reading exceeds the dynamic range of the display and the display polarity matches the polarity selected for the setting. This feature appears to be un-necessary, but it prevents a greater than limit trip from clearing because the display has overflowed through zero. It should be noted that a less than limit trip will also occur with an overflow because the display reading overflows through zero resulting in an apparently low reading. This was deliberately allowed to happen because an overflow condition usually means a fault condition and should be checked into. An overflow is apparent on the front panel display by a lit overflow LED and blanked reading.

Several sets of normally open and normally closed relay contacts are available for connection to external devices. For non critical applications, the two channels can be used separately with separate displays for a dual channel monitor in one module.

The basic range of the analog to digital converter sections which are displayed on the front is zero to one volt. With the four digit display, this gives a basic resolution of 100 microvolts or .01% of full scale. Using the isolated input amplifier, the sensitivity can be increased by a factor of 10 to 1000. Because the particular isolation amplifier used requires a minimum gain setting of 10, provision is made on the board to divide the signal voltage on the output side by any convenient scale factor for system unity gain if required.

4. Results:

After a great deal of effort all of the additional components were squeezed onto a standard NIM compatible circuit board. The resulting module has a much greater range of applications because of the additional features built in. For example a bipolar or reversible power supply current can be monitored and separate trip levels can be set for each polarity.

For additional information refer to TM-944,2817.000, Meson Lab Print Numbers 2816-ED-95150 and 2837-ED-95181.